October 2018
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MPA Materials Matter

INSIDE

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NATIONAL LABORATORY
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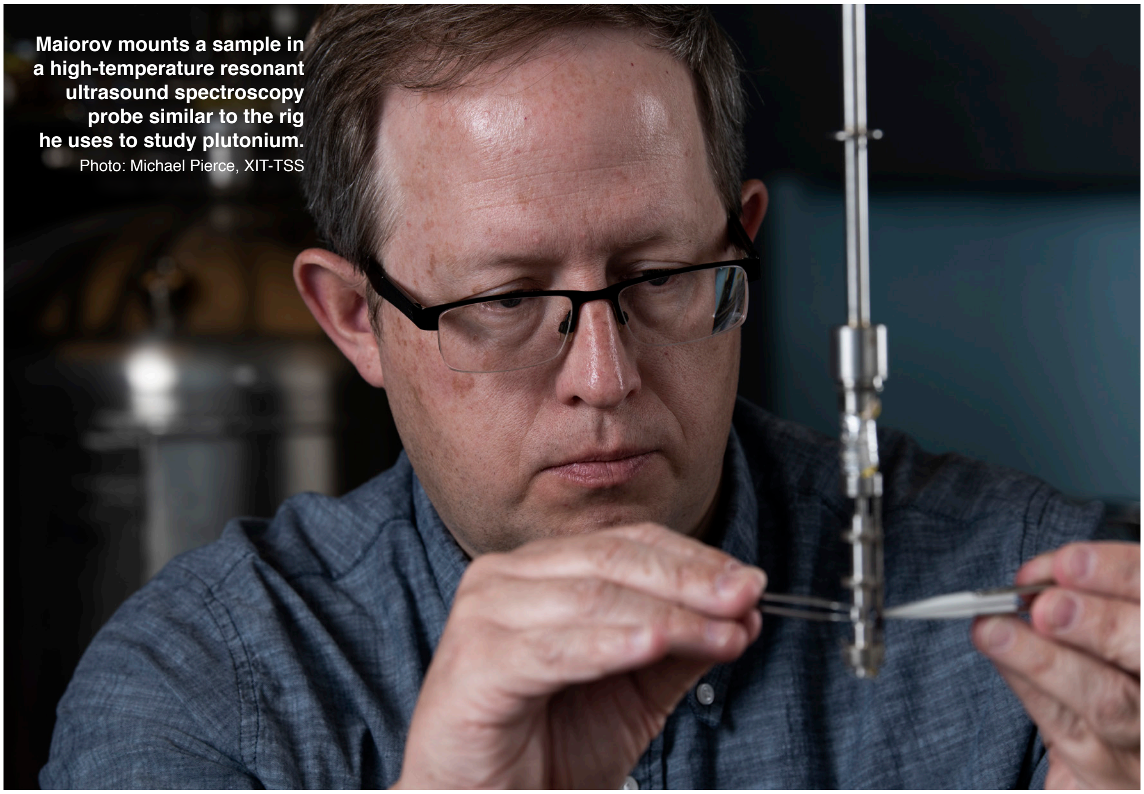

Maiorov mounts a sample in a high-temperature resonant ultrasound spectroscopy probe similar to the rig he uses to study plutonium.
Photo: Michael Pierce, XIT-TSS

Boris Maiorov

Tuning in to understand the mysterious behavior of plutonium

By H. Kris Fronzak, ADEPS Communications

> *"LANL has experts in so many specialties. It's wonderful; it means that I can contribute what I know and draw on their knowledge instead of trying to be an expert in everything."*

Boris Maiorov's life is rich with music. His children and wife play instruments, and he himself has a background in opera and wind instruments. Among his preferred instruments are the trumpet and the moceño, an enormous wooden flute that produces a reedy, orchestral sound and is common in Maiorov's native Argentina.

The music doesn't stop when he comes to work, either. Maiorov, a scientist with the National High Magnetic Field Laboratory-Pulsed Field Facility, is a pioneer in an ultra-sensitive technique tailored at Los Alamos to "hear" changes in materials.

With resonant ultrasound spectroscopy (RUS), experimentalists lightly pin a metal sample between two piezoelectric transducers and shoot sound waves through the setup. The sample resonates in response to different frequencies,

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From Brad's desk . . .

First, for those who I've not had the chance to meet, let me introduce myself. My name is Brad Beck (I go by my middle name–just FYI), and I've been here at LANL since 1992 (I started as a graduate student, and it was great to see all the students here this summer!). Most of my career has been spent working in the Weapons Program, but I have also had the chance to spend several years working with Global Security programs. Most of my scientific work has centered around computational physics and analysis. Furthermore, I have held a variety of leadership roles over the years, with my last assignment serving as the acting deputy program director for the ASC (Advanced Simulation and Computing Program) for almost a year.

When Tanja asked me if I might be interested in serving as the acting deputy division leader while Rick was out for several months, I was very interested. While my background is not in materials science (my Ph.D. is in nuclear engineering), I have always enjoyed learning and working in new areas at the Lab. In meetings with both Rick and Tanja they highlighted all of the excellent science and work going on in the division, and it sounded like a great place to work. After being here a couple of months, I completely agree!

During my first two and a half months here, I have had the chance to work closely with members of the MPA leadership team and I have been incredibly impressed. Their dedication to enabling the outstanding science that is being performed is remarkable. I feel strongly that the group and division leadership positions are some of the hardest leadership jobs at LANL, and in my opinion you have sincerely dedicated and excellent leaders. One of my favorite quotes is from the late Steve Jobs: "It doesn't make sense to hire smart people and tell them what to do; we hire smart people so that they can tell us what to do."

Additionally, I have had the chance to have several "meet and greet" sessions. With the schedule that the division office has I have not had a chance to meet with everyone, although I wish that I could have! I would like to thank everyone that met with me and explained—especially to a person who is not an expert in your area or research—what you are doing. Thank you! During these discussions, it has been greatly illuminating to see the research, your enthusiasm, and the ideas that flow from the research. I continually find myself wondering what changes this research will have on the scientific community and even the world in the coming years.

One of the great things about Los Alamos National Laboratory is the breadth of work that is being done. I have always said that a good day is a day when you learn something new. For me, every day in MPA has been a great day! I have learned a lot and I want to thank you for helping me. Lastly, thank you for the warm welcome and thank you for your dedication!

MPA Deputy Division Leader (acting) Brad Beck

"... it has been greatly illuminating to see the research, your enthusiasm, and the ideas that flow from the research. I continually find myself wondering what changes this research will have on the scientific community and even the world in the coming years."

Brad

Maiorov cont.

similar to a tuning fork, illuminating changes to its elastic properties.

Using RUS, Maiorov can evaluate how defects, which can be caused by aging, change the elasticity of a material. The technique is vastly more sensitive than machine-generated measurements. It can measure changes with a sensitivity of a hundred times better than one in a million.

In short, by listening to sound waves Maiorov can pinpoint changes and determine the stability of materials, such as plutonium. Understanding this material's behavior is essential to the Lab's core mission of stewarding the nation's nuclear stockpile.

RUS work at Los Alamos has led to papers in high-profile journals such as *Proceedings of the National Academy of Science*, *Journal of Applied Physics*, *Journal of Nuclear Materials*, and *Physical Review* and increased the scientific community's knowledge and theoretical models of the electronic structure of plutonium.

Maiorov, who has a Ph.D. in physics from Argentina's Instituto Balseiro, joined Los Alamos as a postdoctoral researcher in 2003 to study vortex pinning in superconductors, which are materials that conduct electricity with no resistance. Since then, he has made breakthroughs that have drastically improved the understanding and performance of these materials and changed how they are grown.

He eventually began collaborating with Los Alamos researcher Albert Migliori, a Lab Fellow and guest scientist with Materials Synthesis and Integrated Devices (MPA-11), who had developed RUS and started using it to study plutonium aging. The technique resonated with Maiorov in part because it was "like making music with plutonium," he said, and because the work was essential to the Lab's mission.

"Plutonium is amazing in a fundamental sense because it behaves unusually and is so rich in behaviors," Maiorov said. "With techniques like RUS, we're working to understand how it ages and behaves in different environments. This knowledge is critical to understanding and predicting the existing stockpile."

To make his discoveries, Maiorov leverages the tools and expertise available at the Los Alamos magnet lab, where leading techniques are developed and high magnetic fields are used to unravel the magnetic contribution to plutonium properties.

"There are still a lot of physics to understand when it comes to plutonium, but mag lab researchers have been developing expertise and techniques for decades, which makes the facility exceptional for this work," Maiorov said. "LANL has experts in so many specialties. It's wonderful; it means that I can contribute what I know and draw on their knowledge instead of trying to be an expert in everything."

Boris Maiorov's favorite experiment

What: Measured real-time stiffening of both elastic moduli of a plutonium sample that had been stored at room temperature for 8 years and was still changing.

Why: Knowing the mechanisms of plutonium aging is a fundamental question we seek to answer. By determining real-time aging in one sample, we can avoid sample-to-sample comparisons.

Who: Jon Betts (NHMFL-PFF) taught me all I know about RUS systems. Albert Migliori introduced me to RUS and plutonium physics and passed on his passion for understanding plutonium. Franz Freibert and several other colleagues in Nuclear Materials Science (MST-16) filled in my gaps of plutonium knowledge and provided the sample.

When: We finished in 2016, after 11 months of continuous measurements.

Where: The NHMFL mag lab. This was my first experiment using a glovebox.

How: We decided to study the effects of aging on the plutonium sample at temperatures that were higher than ambient, which to my knowledge had not been explored before. I looked at the time and temperature dependences of more than 30 resonances to determine the real-time aging of both elastic moduli.

The 'aha' moment: By looking at the time and temperature dependence, I could clearly see the frequencies "going up" at fixed temperature, which indicated stiffening with time.

MPA staff in the news

Yuxiang Chen wins 'Most Fundable Technology' award

Yuxiang Chen

Postdoctoral researcher Yuxiang Chen (Center for Integrated Nanotechnologies, MPA-CINT) was recognized for his outstanding presentation at the 2018 DisrupTech, an event that brought together entrepreneurs, investors, regional leaders, policymakers, and industrial partners learn about potentially disruptive technologies—those that could potentially change the way people live and work—being developed at the Lab.

Chen won the "Most Fundable Technology" award for his presentation on "NanoCluster Beacons: Fast Testing for Food Safety." The award will help Chen improve his technology that quickly and accurately tests for pathogens in food.

This year's event included pitches for 11 different Los Alamos technologies. Materials Synthesis and Integrated Devices (MPA-11) postdoctoral researcher Kannan Ramaiyan presented research on "Cheap and Durable Sensors for Gas Monitoring."

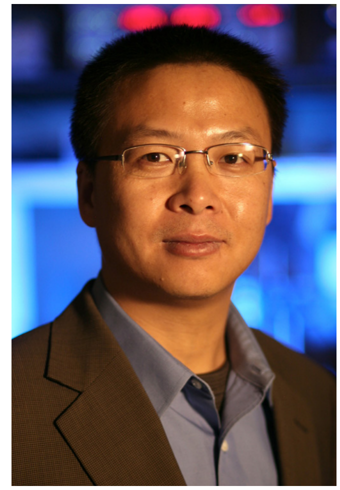
The fourth annual DisrupTech showcase was hosted by the Laboratory's Richard P. Feynman Center for Innovation, New Mexico Angels investor group, and the New Mexico Start-Up Factory. Sponsors included title sponsor EY, the State of New Mexico Economic Development Department, the New Mexico Manufacturing Extension Partnership, the Los Alamos Commerce and Development Corporation, TechNavigator, and Emera Technologies.

Technical contact: Yuxiang Chen

Hou-Tong Chen serves as terahertz sensing subcommittee chair at OSA Advanced Photonics Congress

Hou-Tong Chen (Center for Integrated Nanotechnologies, MPA-CINT) was subcommittee chair for the THz sensing session at the annual OSA Advanced Photonics Congress, held recently in Zurich.

The THz sensing session, part of the Optical Sensors topical meeting, addressed challenges in THz sensors from source and detection technologies, sensor configurations, and processing approaches to applications. Prominent experts in the field presented on topics including THz microfluid chips, metasurfaces for imaging and sensing as well as polarization conversion and beam focusing, field enhancement in nanoantennas, and high-intensity field and strong light-matter interactions.



Hou-Tong Chen

Chen, who has a Ph.D. in physics from Rensselaer Polytechnic Institute, is a fellow of the OSA and the American Physical Society. At Los Alamos, he performs metamaterials research as part of CINT's nanophotonics and optical nanomaterials science thrust.

THz sensing subcommittee members were Enrique Castro Camus (Centro de Investigaciones en Optica, Mexico), Marco Rahm (University of Kaiserslautern, Germany), Giacomo Scalari (ETH Zürich, Switzerland), and Yan Zhang (Capital Normal University, China).

The Optical Sensors topical meeting focused on the R&D applications of optical sensors and their potential in national defense and commercial markets. The OSA Advanced Photonics Congress includes eight topical meeting addressing all aspects of photonic device R&D and the use of such devices in networks. The Optical Society's mission is to promote the generation, application and archiving of knowledge in optics and photonics and to disseminate this knowledge worldwide.

Technical contact: Hou-Tong Chen

Cristian Pantea and Dipen Sinha inducted to Los Alamos Innovation Honor Society

Cristian Pantea and Dipen Sinha (Materials Synthesis and Integrated Devices, MPA-11) have been named to the inaugural class of the Los Alamos Innovation Honor Society.

Created by the Richard P. Feynman Center for Innovation in 2018, the society recognizes outstanding Los Alamos technical staff who have made long-standing contributions to scientific discovery, innovation, and technology transfer. Selection criteria is based on collaborations, protection and deployment of innovation assets, and other considerations such as intellectual property inventions, copyrights, and technology transfer efforts.

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MPA staff cont.

Cristian Pantea

Dipen Sinha

Pantea's technical focus is on ultrasonics, nonlinear acoustics, and solid-state physics. He primarily engages with the Department of Energy. Pantea has numerous patents and applied for his first R&D 100 Award in 2018.

Sinha's technical focus is noninvasive characterization and acoustic manipulation of materials. He primarily engages with Chevron. A Los Alamos National Laboratory Fellow and MPA guest scientist, he is the recipient of multiple R&D 100 awards.

Other Laboratory inductees were Nicholas Dallmann and Pulak Nath (Applied Modern Physics, P-21), Christopher Morris (Subatomic Physics, P-25), Bette Korber and Peter Hraber (Theoretical Biology and Biophysics, T-6), Gary Grider (High Performance Computing, HPC-DO), Stephen Judd (X Theoretical Design, XTD-DO), and Patrick Chain (Biosecurity & Public Health, B-10).

Technical contact: Cristian Pantea

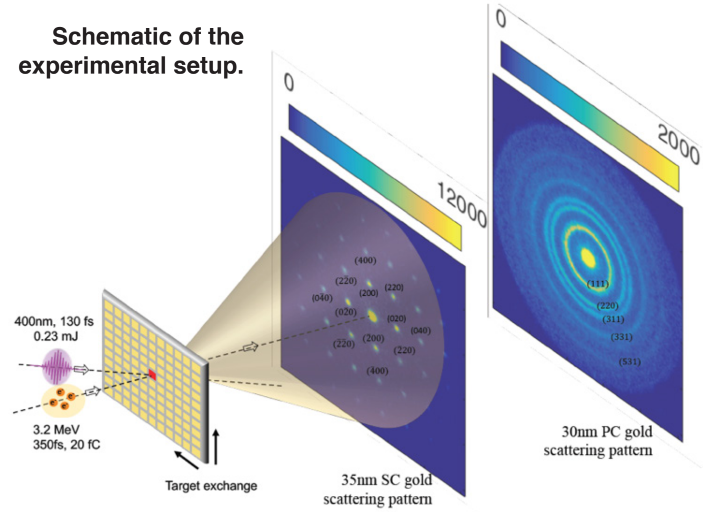
High-speed electron camera captures gold melting at atomic scale

Records heterogeneous melting for the first time

Understanding fast melting of metals is important for welding and micromachining in many applications, including the engineering of fusion power reactors. However, melting happens so quickly that it has historically only been probed on the atomic scale through simulations. Modeling work on gold films has already predicted the existence of distinct melting regimes that have been excited by ultrafast lasers at different energy densities, but experimental data on the phenomenon has not been recorded.

In a study published in *Science*, an international team that included Los Alamos National Laboratory researchers performed ultrafast electron diffraction experiments on laser-pulsed gold films.

Schematic of the experimental setup.



The results provide critical information to test and improve the kinetic theories of melting and help advance the material processing related to solid-liquid phase transition to atomic-level precision. The discovery also requires adding new physical processes to high-energy melting models and may aid development of inertial confinement fusion experiments and other applications that require materials to endure extreme conditions for long periods of time.

Using a modern, high-speed electron camera at SLAC National Accelerator Laboratory, the researchers made the first visualizations of the ultrafast melting of gold on the atomic length scale. The camera provided time-resolved electron diffraction with MeV electrons, enabling measurements with extremely high signal-to-noise ratios that resulted in detailed maps of melting gold.

The data showed that gold melting happens through two distinct regimes while the bonding behavior changes in unexpected ways. For energy densities approaching the irreversible melting regime, the research team observed heterogeneous melting on time scales of 100–1000 ps. This transitioned to homogeneous melting that occurred catastrophically within 10–20 ps at higher energy densities. At intermediate energy densities, the team showed evidence for both solid and liquid coexisting heterogeneously. This was the first observation of heterogeneous melting. The observation enabled direct comparison with molecular dynamics simulations and revealed the sensitivity to nucleation seeds for melting.

The Los Alamos portion of the work was supported by the Department of Energy, the DOE Fusion Energy Sciences Program, and the DOE Basic Energy Sciences' Accelerator and Detector program. Lab researchers were responsible for synthesizing the samples in an ultra-high vacuum electron beam evaporation system located at CINT. The work supports the Laboratory's Stockpile Stewardship and

continued on next page

High-speed camera cont.

fundamental science mission areas and its Materials for the Future science pillar. CINT is a DOE Office of Basic Energy Sciences user facility jointly operated by Sandia National Laboratories and Los Alamos National Laboratory.

Technical contact: Jon Baldwin

NHMFL-PFF upgrades deliver more consistent, reliable power, supporting mission delivery

The National High Magnetic Field Laboratory-Pulsed Field Facility's 1.4-billion-watt generator system has recently received sophisticated electrical and mechanical equipment upgrades that will ensure the facility delivers on its fundamental and national security science missions for decades to come.

The generator is capable of producing a pulse of electrical energy of 170 million J (the energy equivalent to about 85 sticks of dynamite) and has operated at the magnet lab since the early 1990s.

Los Alamos staff and technical personnel from ASEA Brown Boveri and General Electric have completed two of three planned phases of the generator modernization. For the first phase, a specialized team disassembled most of the collector ring end of the generator to expose both poles of 40-inch chromium-vanadium rings.

This involved deenergizing the drive, setting up a lockout-tagout of the machine, and abating asbestos-loaded gaskets. General Electric personnel then mounted a GE-owned sliding grinder driven by compressed air. The rings were ground and hand-polished for almost three days. Because the machine was on and gears were turning during polishing, engineers from Los Alamos and General Electric had to closely supervise the polishing before reassembly.

In the second phase of generator upgrades, four members of ASEA Brown Boveri helped engineer and manufacture electrical components that are central to the generator's power delivery capabilities. These components are state-of-the-art versions of the exciter and driver systems that the machine has used since it was commissioned almost 30 years ago.

The first two phases of this modernization project cost $1.7 million and mark the first steps toward enabling the machine to deliver the power needed to stay atop a highly competitive international arena. A third phase is ongoing to address aging and general wear of the generator's sophisticated oil lubrication system.

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Lab employees are collaborating with General Electric and ASEA Brown Boveri to modernize the National High Magnetic Field Laboratory-Pulsed Field Facility's custom-made, 1.4-billion-watt generator system. The motor generator was manufactured in Switzerland and designed for a nuclear power plant of the Tennessee Valley Authority. Los Alamos acquired the generator for $1 with the caveat that the Lab was responsible for transporting the machine to New Mexico. The generator, moved in the early 1990s, is the heaviest load ever transported on New Mexico roads.

Millwright Harry Sims (NHMFL-PFF) cleans excitation brush rigging to prepare for collector ring grinding.

NHMFL-PFF cont.

The National High Magnetic Field Laboratory-Pulsed Field Facility (NHMFL-PFF) is one of three campuses of the NHMFL, the nation's premier institution for high magnetic field science. NHMFL-PFF has the highest-magnetic-field-intensity research magnets and specializes in science in "pulsed" magnet fields. It operates an international users program for research in high magnetic fields and has the world's only research program that has delivered scientific results in nondestructive magnetic fields up to and exceeding 100 T.

For the Laboratory, the NHMFL-PFF makes available the highest magnetic fields for scientific research and develops the related technologies to advance high-field magnet science for the future. This research supports the Lab's Energy and Stockpile Stewardship missions, including its Materials for the Future science pillar by helping to develop materials with predictable performance and controlled functionality, the central vision of the Laboratory's materials strategy.

The upgrade delivers more consistent and reliable power to the facility's long-pulse 60-T magnets and flagship 100-T multi-shot magnet and will benefit research performed as part of the mag lab's user program, the DOE Basic Energy Science "Science at 100 T" program, and the Laboratory Directed Research and Development program. Research performed at the mag lab includes studies of materials with unique functions and applications, such as high-temperature superconductors, topological semimetals and insulators, and quantum magnets.

The upgrade required essential contributions from staff from across the Laboratory with expertise in a range of disciplines. Contributing to the complex modernization effort were Mark Hinrichs, Mike Pacheco, James Michel, Jason Lucero, Marcos Vigil, Darrel Roybal, Hazuki Teshima, Chris Cordova, Michael Gordon, Jeffrey Martin, Julie Gallegos, Jonathan Betts, Ross McDonald, and Marcelo Jaime (NHMFL-PFF); Myra Stafford, (DESHF-Science and Technology Operations, DESHF-STO); Rocco Intriere and Logan Robinson (Science and Technology Operations, MSS-STO); John Urban (Industrial Safety and Hygiene, OSH-ISH); Veronica Cisneros (Purchasing, ASM-PUR).

The upgrade was funded through the Laboratory's Institutional support via the Operations Infrastructure Program Office (LANL Program Director Ken Schlindwein). The NHMFL is sponsored primarily by the National Science Foundation, Division of Materials Research, with additional support from the State of Florida and the U.S. Department of Energy.

Technical contact: Marcelo Jaime

HeadsUP!

What to know and expect before you dial 911

Big tip: Always use the technical area and building numbers instead of acronyms and building names when reporting emergency locations.

See a snake? Snake bite?

If you encounter a rattlesnake, do not try to move or kill it yourself. The Lab's Pest Control unit handles snake control and will quickly and safely remove the snake for you. Call 7-PEST for assistance.

Individual reactions to snake bites can vary—call 911 and get to the hospital ASAP. Do not try to kill or take a photo of the snake and do not treat the bite yourself. If a bite occurs during work hours, get treated first and then notify your supervisor.

Celebrating service

Congratulations to the following MPA Division employees celebrating recent service anniversaries:

Michael Hundley, MPA-CMMS .... 35 years
Linda Chavez, MPA-CINT .... 15 years
Rohit Prasankumar, MPA-CINT .... 15 years
Aiping Chen, MPA-CINT .... 5 years

MPA Materials Matter

Materials Physics and Applications

Published by the Experimental Physical Sciences Directorate

To submit news items or for more information, contact Karen Kippen, ADEPS Communications, at 505-606-1822 or adeps-comm@lanl.gov. To read past issues see www.lanl.gov/orgs/mpa/materialsmatter.shtml.

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NNSA National Nuclear Security Administration